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Gracilaria dotyi sp. nov. (Rhodophyta, Gigartinales): a New Intertidal Species from Oahu, Hawaiian Islands[1]

MITCHELL D. HOYLE[2]

ABSTRACT: A new species of *Gracilaria* (*G. dotyi* sp. nov.) is described from Oahu, Hawaiian Islands. The species resembles *G. coronopifolia* but differs in several morphological and anatomical features. It has a surprisingly limited distribution on the southwest coast and is the only truly intertidal species of *Gracilaria* thus far reported from the Hawaiian Islands.

AS THE MARINE ALGAL FLORA of a small area such as the island of Oahu is studied more intensively, species new to science are bound to be discovered. Oftentimes because of unique ecological forces, a species may display a surprisingly narrow range of distribution. The type locality for the new *Gracilaria* species described forthwith is a particularly curious habitat in that at least one other species (*Helminthocladia simplex* Doty & Abbott 1961) is presently known to occur only at that location. Detailed examinations of material first collected by M. S. Doty in 1963 and of later collections have shown that the alga is distinct among the Hawaiian species of *Gracilaria* and seems not to have been heretofore described in the literature. This new alga is described and illustrated here and is named *Gracilaria dotyi* sp. nov. in honor of its discoverer.

Exsiccatae specimens have been prepared from several collections. The habit sketch was made from one such exsiccatum which had been soaked in 10-percent KNO_3. Anatomical drawings were made from semipermanent slides of cross sections of fresh material or from sections of soaked exsiccatae materials. Sections were stained either with 1-percent aniline blue, followed by fixation with 1-percent HCl, or with Delafield's hematoxylin, then were washed and mounted in 25-percent Karo syrup as semipermanent slides for microscopic examination.

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Gracilaria dotyi sp. nov.

Thalli erecti, paululum laxi, 2–6 cm alti, omnino teretes, formantes caespites densos e complexione conjuncta tenaculorum singulorum exorientes. Irregulariter formata pulvinata tenacula axes dominantes ramificantes atque breves axes (minus quam 1 cm) non ramificantes emittent. Dominantes axes facientes ramulos intra 1–2 mm super tenacula, tum unusquisque ramulus denuo faciens ramulos 3-vel 4-plo 40–130 mm super primum dichotomum. Ramificatio paululum variabilis sed plerumque dichotoma. Diameter maioris axis ad basim 600–750 mm, latitudo decrescens gradatim terminans distaliter in apice acuto.

Interna anatomia typica generis. Cuticula 13–15 mm crassa. Cortex compositus 1–2 (plerumque 1) stratorum cellulosorum. Cellulae isodiametrae subcorticales (15–26 mm in diametro contiguae corticis) celeriter centripete fieri centrales cellulas 120–150 mm in diametro augent. Transsectione medullae 6–8 cellulae cum parietibus cellularum 4.4 mm crassis videntur. Cellulae medullae impletae plastidibus sphaericis 2 mm in diametro.

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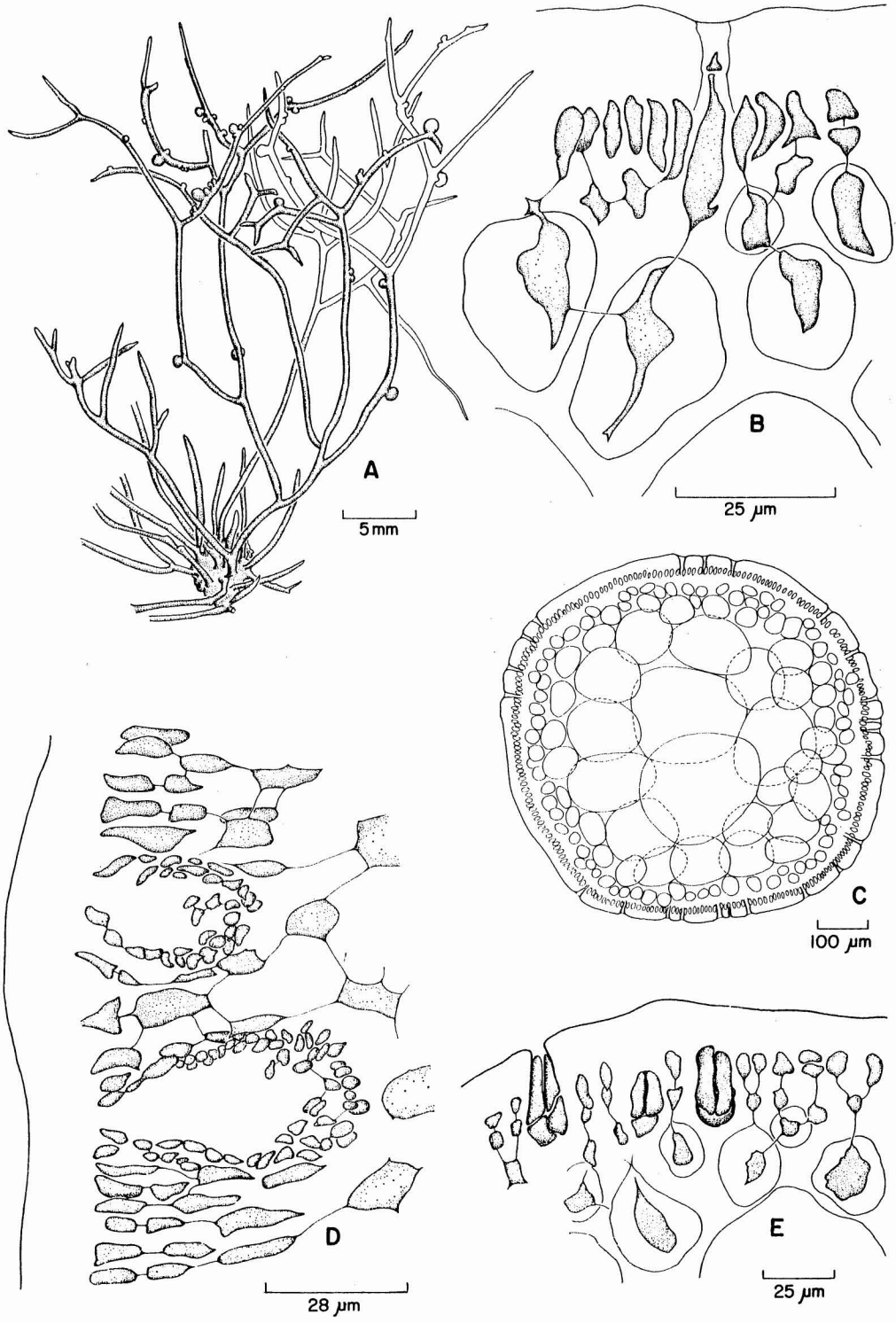
[2] University of Hawaii, Department of Botany, 3190 Maile Way, Honolulu, Hawaii 96822. Present address: Humboldt State University, Department of Biology, Arcata, California 95521.


A
5 mm
B
25 µm
C
100 µm
D
28 µm
E
25 µm

Cystocarpia globosa, 400–900 mm in diametro, moderate constricta ad basim ostiaria sed non rostrata. Gravis gonimoblastus cum numerosis nutriciis filamentis extensis in pericarpium. Ovales carposporae 51.4 × 19.8 mm ad maturationem. Sori spermatangi in marsupiiformibus conceptaculis, 30 mm in diametro et usque ad 55 mm profundum cum spermatiis 2–3 mm in diametro: nihil modificationis corticis circum conceptacula. Dispersa cruciata tetrasporangia (19–26 × 26–40 mm) in cortice inclusa et in subcortice: nihil modificationis corticis circum tetrasporangia.

Description

Thalli erect but somewhat lax, 2–6 cm tall, terete throughout, distal portions buff-colored becoming brownish or maroon toward the holdfast (colors based on nomenclature in Ridgway 1886), forming dense tufts arising from a fused complex of holdfasts. The individual irregular shaped pulvinate holdfast usually has only one dominant branching axis and 1 to 3 or 4 short (less than 1 cm) unbranched axes arising from it. Individual holdfasts fuse almost imperceptibly into one another to form an expansive cushion about 1 mm thick. Branching is infrequent and somewhat variable due to regrowth following injury, but is mostly dichotomous in one plane throughout: occasionally pseudodichotomous or secund branches develop. A dominant axis branches dichotomously (Figure 1*A*) almost immediately (within 1–2 mm above the holdfast) and each of these branches may then branch 3 or 4 more times 70–130 mm above the first dichotomy. The diameter of a major axis at the base is 600–750 μm, the diameter gradually decreases distally and terminates in an acute apex. Cystocarpic thalli are often slightly geniculate at the point of cystocarp attachment. Sterile and tetrasporic thalli are morphologically indistinguishable. The male thalli examined are somewhat shorter and smaller in diameter than female, tetrasporic or sterile thalli. The alga adheres well to paper on drying.

Internal anatomy is typical of the genus. Lying beneath a cuticle 13–15 μm thick, the cortex is composed of 1–2 (mostly 1) layers of dark staining cells, the outer layer of which is palisade-like, being made up of anticlinally elongated cells about 6.6–8.8 μm × 4.4 μm. Subtending the cortex are irregularly to isodiametrically shaped cells about 4.4 μm in diameter. These subcortical cells may be elongated to 8.8–13.2 μm × 4.4 μm as seen in some thalli. In tangential surface view colorless hairs are seen to protrude from the cortex through the cuticle, terminating in a shallow depression in the cuticle. No hairs were seen protruding beyond the cuticle in stained preparations and are presumed to break off during the staining process. In cross sections of thalli, hair cell bases (Figure 1*B*) 6.6 μm in diameter and up to 17.6 μm long with a cap atop a constricted neck extending into the cuticle stain with aniline blue more darkly than do the surrounding cortical cells. A hair cell is supported by a medullary cell and has pit connections with several other cortical and medullary cells.

Isodiametric medullary cells adjacent to subcortical cells are 15–22 μm in diameter. Cell walls are 4.4 μm thick, or 8.8 μm between two adjacent cells. Medullary cells enlarge quickly centripetally to central cells 88–150 μm in diameter. The medulla is 6–8 cells across (Figure 1*C*), and the cells are filled with spherical plastids 2 μm in diameter. Some material shows vacuolate medullary cells with the cytoplasm appressed to the cell walls.

Cystocarps are globose (400–900 μm in diameter), moderately constricted at the base, and ostiolate, but nonrostrate. A massive gonimoblast has numerous nutritive filaments up to 176 μm long, extending into the pericarp and connecting via pit connections to the vegetative cells of the pericarp. Mature oval carpospores (19.8 × 15.4 μm in diameter) contain about six

FIGURE 1. *A*, habit sketch of a cystocarpic thallus, *Doty* 20089; *B*, cross section of a sterile thallus showing a hair cell base extending into a pore in the cuticle, *Hoyle* 832; *C*, cross section of a sterile thallus showing the Macrocystideae type medulla and hair pores in the cuticle, *Hoyle* 832; *D*, cross section of a male thallus showing pocket-shaped spermatangial conceptacles, *Abbott* 4325; *E*, cross section of a tetrasporic thallus showing a tetrasporangium protruding toward the surface through a pore in the cuticle, *Hoyle* 832.

spherical bodies 2–4 μm in diameter. Spermatangial conceptacles in surface view appear as independent oval (60 × 40 μm) or circular (20–50 μm in diameter) patches surrounded by as little as one layer of cortical cells. In cross section, the pocket-shaped spermatangial conceptacles (Figure 1*D*) are up to 30 μm in diameter and up to 55 μm deep, embedded in the cortex and subcortical medulla and lined by a single layer of irregular shaped cells (3 × 5 μm), each bearing a single rounded (2–3 μm in diameter) spermatium. There is little or no modification of the cortical cells around the spermatangial conceptacles. Cruciate tetrasporangia (19–26 μm × 26–40 μm) are scattered and embedded (Figure 1*E*) in the subcortical medulla and cortex. Many tetrasporangia are elongated, extending into the cuticle and to the thallus surface through a pore. Darker staining stellate structures are visible in some tetraspores, but most tetraspores contain rounded bodies 2–4 μm in diameter.

Holotype

M. S. Doty 20089. Cystocarpic thalli deposited in the herbarium of M. S. Doty at the University of Hawaii.

Isotype

M. S. Doty 20089. Cystocarpic thalli deposited at the University of California at Berkeley.

Topotypes

Deposited in the herbarium of M. S. Doty at the University of Hawaii (*M. S. Doty* 31550, male thalli; *I. A. Abbott* 4325, male thalli; *M. S. Doty* 24669, tetrasporic thalli; *M. D. Hoyle* 832, tetrasporic thalli) and at the University of California at Berkeley (*M. D. Hoyle* 832).

Type Locality

On central seaward edge of nearly horizontal, wave-washed sandstone bench at Kahanahaiki, Waianae District, Oahu, Hawaiian Islands.

Additional Material

Deposited in the herbarium of M. S. Doty at the University of Hawaii (*M. S. Doty* 31563, green turtle gut contents).

Remarks

Specimens of *Gracilaria dotyi* are found throughout the year on the wave-swept sandstone bench located toward the western end of the beach at Kahanahaiki near Kaena Point on the island of Oahu, Hawaii. The alga is found as small tufts of thalli exposed or in shallow depressions covered by a thin film of water on the almost horizontal bench. The bench is constantly washed by waves even at lowest low water. Distal portions of the sparsely branched thalli are straw color where they are often directly exposed to intense solar irradiation. Shaded portions of the thalli are brownish and become deep burgundy red upon drying.

Of the other *Gracilaria* species in Hawaii, *G. dotyi* superficially resembles only *G. coronopifolia*, differing from the latter in habitat, size, internal (medulla) anatomy, spermatangial conceptacle shape and size, and cystocarpic morphology. Whereas *G. coronopifolia* is almost always subtidal and is from about 4–20 cm tall at maturity, *G. dotyi* is intertidal and only 2–6 cm tall at maturity. The medulla of *G. coronopifolia* is composed of many more cells enlarging gradually centripetally as characteristic of the series Microcystideae (May 1948) whereas the medulla of *G. dotyi* is made up of larger and fewer cells enlarging rapidly centripetally as in the series Macrocystideae. Like *G. coronopifolia*, *G. dotyi* has the Verrucosa type (Yamamoto 1975) of male organ. The spermatangial conceptacles of *G. dotyi* are generally wider (30 μm versus 23 μm) and deeper (55 μm versus 49 μm) than are those of *G. coronopifolia*. Although the cystocarps of both species are constricted at the base, only those of *G. coronopifolia* are rostrate.

In its minuteness the new species resembles *Gracilaria erecta* (Grev.) Grev. as *Gigartina erecta* in Wyatt (1837), but differs from that species in particular in lacking the extensively modified cortical tissue that forms the swollen clavate apices in tetrasporophytic thalli.

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